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INFORMATION FOR HEALTH CARE PROFESSIONALS LEAD EXPOSURE AND TOXICITY

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This document is designed for health care providers and summarizes information on the sources, exposure pathways, laboratory testing, recognition, and reporting of lead exposure and/or poisoning. Louisiana Law requires the [reporting](#) of all cases of lead poisoning and all lead laboratory test results to the Louisiana Department of Health and Hospital's Office of Public Health.



EXPOSURE TO LEAD

Occupational Exposure: Lead is a heavy metal that poses an occupational hazard in a number of industrial settings. Over 90% of adults with elevated blood lead levels are exposed in the workplace (CDC, 2013) and the majority of these through the inhalation of lead-containing dust and fumes. Additional exposures may occur through contact with food, drinks, cigarettes, and clothing contaminated with lead while in the workplace. Occupations with the greatest risk of exposure include battery manufacturing, soldering (electrical components and automobile radiators), refinery workers, lead smelters, sandblasters, and bridge and construction workers (ATSDR, 2015).

The federal government banned the use of lead-based paint in residential construction in 1978. However, no such federal ban exists in commercial construction.

Take-Home Exposure: Workers often transport lead on shoes and work clothes into their homes or automobiles (NIOSH, 2015). "Take-home" lead puts children and spouses at risk for lead exposure and may warrant blood lead testing of the entire family. Young children, pregnant women, and nursing women are of particular concern.

Steps to prevent take-home lead contamination:

- Change shoes and clothes at work before getting into the car or going home. Put dirty work clothes and shoes in a plastic bag.
- Wash face and hands prior to leaving work.
- Shower and wash hair immediately upon arriving home (or before leaving work).
- Wash work clothes separately from the family's clothes and run the washing machine again to rinse residual lead (or have the employer wash clothes).

For documented cases and information regarding take-home lead, refer to the [National Institute for Occupational Health and Safety website](#) or ["Take-Home Lead Exposure Among Children with Relatives Employed at a Battery Recycling Facility- Puerto Rico, 2011"](#) (CDC, 2012).

Exposure Risks to the General Population: The most common source of childhood lead exposure in the United States is from lead-based paint found in homes built before 1978 (HUD, 2009). Both inside and outside the home, deteriorating lead-paint mixes with household dust and soil where it builds up on window sills and floors. Children can become exposed by putting their hands or other lead-contaminated objects into their mouths (CDC, 2015a). Children are more vulnerable to the adverse effects of lead than adults. Pregnant women, nursing women, women who are planning to become pregnant, and parents of young children need to be aware of the options available for reducing lead hazards in the home.

People may be exposed to lead from several sources that may not be readily known or recognized. Renovation of older homes that contain lead-based paint puts families at an increased risk of exposure. Renovation may mobilize lead from paint making it more available for inhalation or ingestion (EPA, 2015; HUD, 2009). This is a factor in areas recovering from damage from Hurricanes Katrina and Rita. Hobbies such as casting ammunition, making fishing weights, and working with stained glass involve lead and are potential sources of exposure. People who live near battery recycling or crushing centers, or other industrial lead sources may also be at an increased risk of exposure through air, soil, dust or water contamination (ATSDR, 2015).

Examples of Sources of Lead Exposure	
OCCUPATIONAL	NON-OCCUPATIONAL
Auto body painting/repair	Casting lead (bullets, fishing sinkers, toys)
Construction, Repair of bridges/tunnels/highways	Car repairs
Battery Manufacturing/Repair	Ceramic glaze
Demolition/renovation	Remodeling/Renovating
Lead abatement	Shooting firearms
Metal Work (casting, blasting, grinding, buffing)	Stained glass work
Mining	Retained bullet or fragment
Painting-commercial/residential	Traditional and folk medicines (azarcon, greta, pay-loo-ah, alarcon, ghasard, alkohl, liga)
Paint/pigment manufacturing	Ingesting contaminated soil or well water
Printing	Moonshine
Radiator repair	Lead glazed tableware/cookware
Refining	Deteriorating lead paint
Sandblasting	Living near landfills & hazardous waste storage/release sites
Scrap metal recycling	Pica (ingesting lead containing nonfood items)
Ship building	
Soldering	
Utilities	
Welding	

This is not a complete list of exposure sources. The above information was compiled from: CDC 2013, 2015b; ATSDR, 2015.

TOXICITY OF LEAD

Lead is one of the few heavy metals that have no beneficial use in the body and its toxic effects are well documented. Lead affects many organ systems over a wide range of dose levels. In the adult, chronic lead exposure may result in adverse effects in neurological, hematological, renal, cardiovascular, gastrointestinal, and reproductive systems (ATSDR, 2015). There is wide variability among individuals in the symptoms and responses to lead poisoning.

Lead poisoning usually occurs from chronic exposure. The degree and severity of effects depend on the dose and duration of exposure. Symptoms differ among individuals and do not always occur at specific dose levels. Reported symptoms of lead poisoning in adults include headache; anorexia; weakness; excessive tiredness; irritability; difficulty concentrating; constipation; abdominal discomfort; fine tremors; reduced sex drive; and weakness in fingers, wrists, or ankles (ATSDR, 2015). However, lead poisoning is often a "silent disease" where symptoms are not observed until serious damage has occurred. Diagnosis should not rely on the appearance of symptoms. The only way to determine lead poisoning is by testing for lead levels in blood.

As more knowledge has been gained about dose levels associated with the health effects of lead, the regulatory guidance and recommendations for lead exposure have been lowered. Blood lead levels once thought to be safe have

been shown to exert adverse effects in large population studies. Blood lead levels of concern for both occupational and childhood exposures have decreased over the last 20 years.

Susceptible Populations: Children are more vulnerable to the effects of lead because 1) children absorb greater amounts of ingested lead (40-50% as compared to 3-10% in adults), 2) the blood brain barrier is not yet developed and lead is distributed to the central nervous system, and 3) the developing nervous system is very susceptible to adverse effects of lead (ATSDR, 2015). *In utero* exposure may also result in neurodevelopmental effects, so pregnant women and women planning to become pregnant should limit exposure more than other adults to protect the fetus. Exposure during infancy or childhood may result in delays or impairment of neurological development, neurobehavioral and cognitive deficits, and at higher levels, anemia and renal alterations (ATSDR, 2015). Information on childhood lead poisoning can be obtained from the [Louisiana Healthy Homes & Childhood Lead Poisoning Prevention Program](#) and the [CDC's Childhood Lead Poisoning Prevention Program](#).

Lead-Induced Health Effects in Adults						
BLL (ug/dL)	Hematological	Neurological	Renal	Reproductive	Endocrine	Cardiovascular
>100		Encephalopathic signs and symptoms				
80	Frank anemia					
60				Female reproductive effects		
50	Depressed Hemoglobin					
40		Subencephalopathic CNS effects Peripheral Neuropathy Cognitive deficits	Chronic nephropathy	Altered testicular function	Altered Thyroid Hormone	
30		Peripheral nerve dysfunction	Enzymuria/proteinuria			
20	Erythrocyte protoporphyrin elevation					
10						
<10	ALA-D inhibition		Depressed glomerular filtration			Hypertension

Lead-induced health-effects are listed at the lowest observed effect level. Information compiled from ATSDR, 2015.

EVALUATION OF LEAD POISONING

Assessment of a patient for lead poisoning requires the following

- Work history and identification of possible lead exposure sources
- Medical history
- Laboratory testing for lead

Work and Exposure History: Often, patients do not recognize that they have been exposed to lead unless directly asked about their work environment and activities. A detailed occupational and environmental exposure history is a fundamental step toward acquiring information on possible exposures to lead.

- A full work history is necessary to identify jobs with possible lead exposures. Ask patients about their job (where they work and what they do), potential exposure occurring in current and previous jobs, hygiene practices in the workplace, and use of any personal protective equipment. If the individual is employed in a

job that may involve exposure to lead, further questions on length of time at the job, frequency of tasks handling lead materials, and descriptions of how they carry out their work should be asked.

- An environmental history can identify other potential exposure sources. Questions about age and condition of housing; hobbies (e.g. casting ammunition, making fishing weights, and stained glass); use of traditional medications; and spouse's occupation and the potential for "take-home" lead exposure.

The Agency for Toxic Substances & Disease Registry (ATSDR) has a self-instructional module on "[Taking an Exposure History](#)". An exposure history form is provided in Appendix 1 of this document.

Medical History: A medical history may help to recognize possible symptoms that could be associated with lead poisoning. Early symptoms of lead toxicity in adults might include headache; anorexia; weakness; excessive tiredness; irritability; difficulty concentrating; constipation; abdominal discomfort; fine tremors; reduced sex drive; and weakness in fingers, wrists, or ankles (ATSDR, 2015). Laboratory testing for lead should be considered if the exposure history indicates possible lead exposure and/or the patient is experiencing symptoms that suggest possible lead poisoning.

Laboratory Tests: A laboratory blood test is the only way to confirm lead poisoning.

- **Blood Lead Level (BLL)** is a direct measure of lead in blood and confirms exposure. The BLL is more sensitive than indirect measures of lead exposure such as ZPP (see below). BLL measures the amount of lead in the blood at the time of the test, so it indicates recent exposure and does not provide information on the long-term body burden of lead. The results of the test can be compared to the levels outlined in the [Health-Based Requirements, Recommendations, and Guidelines](#) section to determine if exposure prevention measures and/or medical follow-up are necessary. A BLL should be repeated for individuals with elevated lead levels to monitor changes in the exposure or effectiveness of workplace preventive measures.
- **Zinc protoporphyrin (ZPP)** measures the inhibitory effects of lead on heme synthesis and is an indirect measure of lead toxicity. Lead inhibits the enzyme ferrochelatase which increases free erythrocyte protoporphyrin (FEP) in blood which then binds to zinc to yield ZPP. There is an exponential relationship between a BLL above 40µg/dL and the associated ZPP level. Increases in ZPP are not detectable until a BLL is at or above 25µg/dL. ZPP levels decline more slowly than BLLs. The ZPP was the standard when OSHA regulations were passed and remains a required test. The BLL is often used in conjunction with a ZPP because of its greater sensitivity.

HEALTH BASED REQUIREMENTS, RECOMMENDATIONS, and GUIDELINES

Occupational Safety and Health Administration: The Occupational Safety and Health Administration (OSHA) promulgates and enforces regulations for toxic substances in the workplace. These regulations are enforceable by law. The OSHA lead standards were passed in 1978 for general industry and in 1993 for construction (OSHA, 2014). OSHA regulations are based on both air monitoring and biological monitoring of the worker. Medical surveillance requirements are determined by a worker's exposure to lead in the air, by a worker's BLL and, in the construction industry, by work involving certain high exposure "trigger tasks" (see below for examples) (OSHA, 2014).

General Industry

- The employer must perform personal air sampling if employees are exposed to lead at work. Employees exposed at or above 30µg/m³ (eight-hour time weighted average) for more than 30 days per year must be enrolled in a medical surveillance program that includes BLL and ZPP monitoring every six months.
- Employees with a BLL at or above 40µg/dL must continue in this medical surveillance program and have repeat BLL and ZPP testing every 2 months until two consecutive BLLs fall below 40µg/dL.
- An employee is to be removed from the exposure situation and entered into a medical removal program if any of the following are true:
 - 1) A single BLL at or over 60 µg/dL;

- 2) The average of the previous three BLL or the average of all blood lead determinations conducted during the previous six months (which ever covers a longer time period) is $\geq 50 \mu\text{g/dL}$, unless the most recent test is $< 40 \mu\text{g/dL}$;
- 3) The employee has a detected medical condition that places him or her at increased risk from lead exposure.

During medical removal, medical surveillance is to continue and include monthly BLL and ZPP testing. The employee shall remain on medical removal until two consecutive BLLs are at or below $40 \mu\text{g/dL}$ and the physician authorizes return to work (authorization is based on measures taken by the employer to control lead exposure and if the employee's symptoms or any other clinical manifestations of toxicity have resolved).

Construction

- Initial medical surveillance consisting of BLL and ZPP testing is required for:
 - 1) Any employee who is exposed to airborne lead at or above $30 \mu\text{g/m}^3$ (eight-hour time weighted average) on any one day;
 - 2) Any employee who performs certain high exposure "trigger tasks" such as sanding, abrasive blasting, torch cutting, welding, or demolition.

If the BLL falls between $40\text{--}49 \mu\text{g/dL}$, BLL testing should be performed every two months until two consecutive BLLs are below $40 \mu\text{g/dL}$.
- If an employee's airborne lead exposure is at or above $30 \mu\text{g/m}^3$ (eight hour time weighted average) for more than 30 days per year and
 - 1) Has a BLL $\leq 40 \mu\text{g/dL}$, BLL and ZPP testing should be performed every two months for six months, then every six months thereafter or,
 - 2) Has a BLL between $40\text{--}49 \mu\text{g/dL}$, annual medical examinations should be performed and BLL and ZPP testing conducted every 2 months until two consecutive BLLs are below $40 \mu\text{g/dL}$.
- The employee must be removed from the exposure situation and entered into a medical removal protection program if:
 - 1) A single BLL $\geq 50 \mu\text{g/dL}$ or,
 - 2) The employee has a detected medical condition that places him or her at increased risk from lead exposure.

During medical removal, medical surveillance should continue and include monthly BLL and ZPP testing. The employee shall remain on medical removal until two consecutive BLLs are at or below $40 \mu\text{g/dL}$ and the physician authorizes return to work (authorization is based on measures taken by the employer to control lead exposure and if the employee's symptoms or any other clinical manifestations of toxicity have resolved).

Special Considerations for Adults of Reproductive Age: Special OSHA standards exist for pregnant women and male or female workers who intend to parent a child in the near future.

- An individual's BLL should be maintained below $30 \mu\text{g/dL}$ to avoid possible adverse reproductive health effects.
- Physicians may make recommendations for special protective measures including medical removal or decreased daily exposure. These recommendations may be more stringent than the provisions of the OSHA standard.

OSHA released a Windows-based system of elaw advisors directed at assisting the general public with applying the biological monitoring provisions of the OSHA Lead Standard. There are currently two lead-specific elaws: [Lead in General Industry](#) and [Lead in Construction](#).

American Conference of Governmental Industrial Hygienists: The American Conference of Governmental Industrial Hygienists (ACGIH) is a non-profit, nongovernmental scientific organization which develops peer-reviewed guidelines for workplace exposures. These guidelines are considered best practices for protecting workers health, but are not legally enforceable (ACGIH, 2012).

- ACGIH develops Biological Exposure Indices (BEIs[®]) as guidance values for assessing biological monitoring results. The BEI[®] generally indicates a concentration below which nearly all workers should not experience adverse health effects.
- ACGIH has developed a BEI[®] of $30 \mu\text{g/dL}$ (lead in blood) for adult workers.

- The ACGIH cautions that pregnant women with a BLL >10µg/dL are at risk of delivering a child with a BLL ≥10µg/dL (ACGIH, 2012).

Centers for Disease Control and Prevention: The US Public Health Service agencies provide guidance and set national goals for improving health and preventing disease and injury. The Centers for Disease Control and Prevention (CDC) has established the following guidelines for lead.

- The “Healthy People 2020” (DHHS, 2015) sets national goals and strategies for improving health and preventing illness and injury and aims to reduce BLLs of all lead-exposed workers to below 10 µg/dl.
- The CDC’s Childhood Lead Poisoning and Prevention Program defines an elevated blood lead level in children as ≥ 5 µg/dL (CDC, 2015a).

Association of Occupational and Environmental Clinics: The Association of Occupational and Environmental Clinics (AOEC), a non-profit organization that networks occupational clinics and medical practice, uses information sharing and collaborative research to improve the practice of occupational and environmental health. In 2005, AOEC put forth medical management recommendations for adults with lead exposure (AOEC, 2007).

- AOEC recommends that both blood lead testing and action to remove workers from exposure begin when lead levels are approximately 40 - 50% of the OSHA regulations.
- Extends medical monitoring to include all workers who handle or disturb lead-containing materials in addition to those exposed to high levels of airborne lead.
- For more detail on these recommendations refer to the [AOEC Medical Management Guidelines for Lead-Exposed Adults](#) (AOEC, 2007) or “[Recommendations for Medical Management of Adult Lead Exposure](#)”—a document written by a subset of the AOEC lead panel (Kosnett, 2007).

Fourth National Report on Human Exposure to Environmental Chemicals: The “Fourth National Report on Human Exposure to Environmental Chemicals” (CDC, 2015b) provides an assessment of the exposure of the U.S. population to environmental chemicals using biomonitoring. One of the primary purposes of this report is to establish reference ranges that can be used by physicians to determine whether an individual has been exposed to higher levels than are found in the general population. Lead levels in blood and urine samples from a random sample of participants from the National Health and Nutrition Examination Survey (NHANES) conducted by the Centers for Disease Control and Prevention’s National Center for Health Statistics are shown in the table below. People who are occupationally exposed may have higher background levels than those found in the general population.

Background Lead Levels			
	Children <6 yrs	Children 6-11yrs	Adults >20yrs
Blood (ug/dL)	2.9 (2.41-3.83)	1.9 (1.03-1.16)	3.4 (2.98-3.93)
Urine (ug/L)	ND	1.5 (1.28-1.85)	1.6 (1.28-1.90)
Urine (ug/g creatinine)	ND	1.6 (1.12-2.22)	1.6 (1.28-1.87)

Average background levels in a representative sample of the U.S. population 2003-2010 (CDC, 2015b). ND means not determined; (95% confidence interval).

Louisiana Lead Poisoning Reporting Requirements

The State of Louisiana mandates that all cases of lead poisoning and all laboratory lead test results (regardless of the blood lead level) be reported to the Louisiana Office of Public Health. Lead poisoning cases are defined as, “any medical condition/visit resulting from exposure as determined from the exposure history or patient statement and/or acute, subacute, or chronic illness or injury resulting from inhalation, ingestion, dermal exposure or ocular contact.”

- Cases of adult lead poisoning must be reported to the Office of Public Health’s Section of Environmental Epidemiology and Toxicology via
fax (504)568-8149
telephone 888-293-7020 (business hours) or (504)568-8159
[Reporting Form](#)
- Cases of childhood lead poisoning should be directly reported to the Louisiana Childhood Lead Poisoning Prevention Program within 48h after diagnosis. The Childhood Lead Program can be reached at (504)568-8254. Reporting forms and additional information can be found on their [website](#).

CONTINUING EDUCATION

The Agency for Toxic Substances & Disease Registry (ATSDR) offers self-instructional [Case Studies in Environmental Medicine](#) designed to increase the health care provider’s knowledge of lead (and other hazardous substances) in the environment and to aid in the evaluation of potentially exposed patients. Continuing medical education credits, continuing nursing education units, and continuing education units are offered by ATSDR in support of this series.

SOURCES OF INFORMATION

The [Agency for Toxic Substances and Disease Registry](#) (ATSDR) is a federal public health agency focused on providing trusted health information to prevent harmful exposures and diseases related to toxic substances. Succinct fact sheets, detailed documents, and educational resources regarding lead exposure and toxicity can be found on their website.

The [Centers for Disease Control and Prevention Childhood Lead Poisoning Prevention Program](#) is a federal public health program committed to eliminating elevated blood lead levels in children. Information regarding lead exposure sources, toy recalls, and how to test a toy for lead can be found on their website.

The [Louisiana Department of Environmental Quality](#) provides a number of lead fact sheets containing important information on lead-based paint, lead poisoning/hazards, work practices, cleanup of waste, protection for family, and lead disclosure when buying or selling a home.

The [Louisiana Healthy Homes & Childhood Lead Poisoning Prevention Program](#) (LHHCLPPP) aims to eliminate childhood lead poisoning in Louisiana through a comprehensive approach to prevention of lead poisoning and the management of children found to have elevated blood levels. They offer a number of services including monitoring of blood lead levels in children, environmental inspection for children with elevated blood lead levels, and community and professional education on childhood lead poisoning. Medical provider information (guidelines and management, lead case reporting forms, lead poisoning risk assessment questionnaire), educational materials for the general public, and laws and regulations concerning lead poisoning prevention in Louisiana are available on their website.

The **National Institute for Occupational Safety and Health** (NIOSH) is a federal agency established to help assure safe and healthful working conditions by providing research, information, education, and training in the field of occupational safety and health. Information on occupational lead exposure, take-home lead, and the Adult Blood Lead Epidemiology Surveillance (ABLES) Program aimed at reducing adult blood lead levels across the US can be found on their website.

The **US Department of Housing and Urban Development** (HUD) offers a number of resources regarding lead hazards in the home including information for parents on lead-based paint and a manual concerning the safe rehabilitation of hurricane-damaged homes. Information is available in English and Spanish.

The **US Department of Labor's Occupational Safety & Health Administration** (OSHA) develops and enforces regulations for toxic substances in the workplace. Occupational standards and medical monitoring standards for occupational lead exposure can be found on their website.

The **US Environmental Protection Agency** provides the general public and professionals with information about lead hazards and their prevention. This includes information on lead in drinking water, toy recalls, commercially available lead test kits, and protection during home renovations. Information can be found in English and Spanish.

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